Acoustically monitored movement patterns of juvenile Chinook salmon (*Oncorhyncus tshawytscha*) from the Sacramento river watershed during a low flow year

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INTRODUCTION

In the California Fish Tracking Consortium, many different groups are working together to keep the extensive array of acoustic monitors running for tracking fish movement and mortality. The salmon ecology team at NOAA-NMFS South West Fisheries Science Center will be tagging juvenile Chinook salmon (*Oncorhyncus tshawytscha*) and juvenile steelhead (*Oncorhyncus mykiss*) throughout the years 2007-2009, releasing them at different locations on the Sacramento. In the 2007 tagging year, we tagged 200 juvenile late-fall run hatchery Chinook salmon and released them all from the banks of Battle Creek at the Coleman National Fish Hatchery in Anderson, CA.

PROJECT OBJECTIVES

I. **Obtain high-resolution movement data throughout the Sacramento river watershed, delta and San Francisco bay all the way to the Golden Gate Bridge**

II. **Estimate reach-specific mortality data**

III. **Analyze these survival and movement patterns with regards to environmental data**

TOPIC OBJECTIVES

i. **Examine the data allowed by the high-resolution monitor placement, like the possibility of reach-specific swimming speeds**

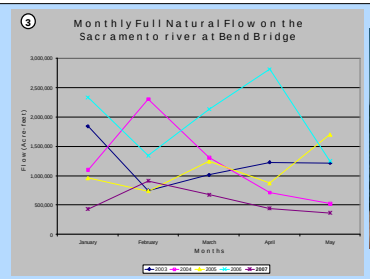
ii. **Determine an average swimming speed and time of travel to the Pacific ocean for juvenile late-fall run Chinook salmon**

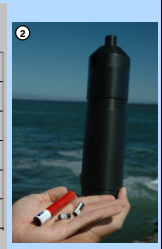
iii. **Compare the movement rates to different environmental variables, such as river flow**

iv. **Hypothesize on the effects of the very low water flow on juvenile Chinook salmon movement, and expand to implications during normal and high water flows.**

THE SYSTEM

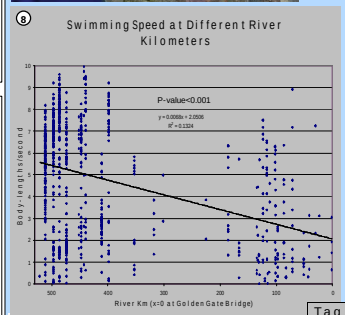
The California Fish Tracking Consortium share more than 200 acoustic monitors that are spread throughout the Sacramento and San Joaquin river systems as well as the delta and San Francisco Bay (1). These monitors can hear and decode the pinging of the ultrasonic acoustic tags as the fish swim by (2). The Sacramento river system had very low flow for the 2007 winter season in comparison to recent history (3). Our tagged Chinook measured an average of 164 mm fork length and weighed an average of 46 grams (4).





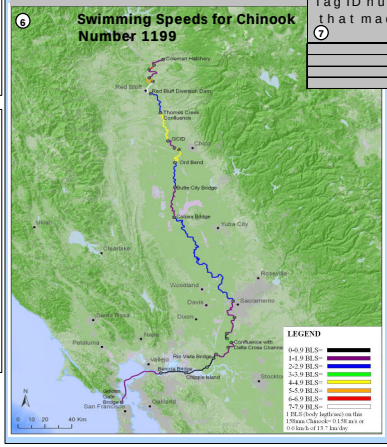
5 Chinook Detected at the following Key Locations or Beyond

Location	River Km	Number of Chinook detected here or beyond	Percent of all Chinook
Red Bluff Diversion Dam	473	74	37
City of Sacramento	187	23	11.5
Rio Vista	103	17	8.5
Benicia Bridge	52	10	5
Golden Gate	0	4	2

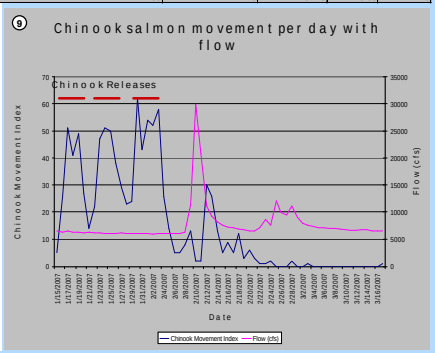


4 Average Chinook's Statistics

	Mean and Standard Deviation
Fork Length (mm)	164.61 +/- 10.78
Weight (grams)	46.47 +/- 9.97
Swimming Speed (meters/sec)	0.784 +/- 0.438
Swimming Speed (BodyLengths/sec)	4.781 +/- 2.703



Tag ID numbers for Chinook that made it to the Golden Gate 7	Days to travel the 527 km	Km/day	m/sec	BL/sec
1178	31	16.65	0.19	1.19
1199	24	21.38	0.25	1.57
1236	25	21.02	0.24	1.49
1299	16	32.79	0.38	2.23



BASIC MOVEMENT SUMMARY

As opposed to our steelhead, our Chinook salmon seem to head straight to the Pacific Ocean right after release. One movement, or in this case survival, pattern that was immediately apparent was the very high mortality in the upper Sacramento river, especially in Battle creek. In fact, only 4 Chinook out of the 200 released made it to the Golden Gate Bridge (5). The mean swimming speed amongst all detected Chinook salmon was 0.8 meters per second, or 4.8 body-lengths per second (4).

HIGH-RESOLUTION MOVEMENT

The sheer number of monitors allows us to make precise calculations of movement patterns and speeds for each individual fish among the thousands (6). For the 4 Chinook that made it to the Golden Gate, it took them an average of 24 days to make it, swimming at an average of 23 kilometers a day (7). A significant correlation (P-value <0.001) between swimming speed and the river-kilometers of the monitors show that the fish move faster *over ground* in the upper river than they do in the delta and bay (8). This could simply be explained by the faster water velocities in the upper river, in which case this could indicate that the Chinook take advantage of the current for their downstream migration.

FLOW EFFECT ON MOVEMENT

There seems to be more overall juvenile Chinook salmon movement during the days of the fish releases and on the few days following a big pulse in flow on February 10th (9). It seems the fish move right away after release and then either stay put, die or are no longer detected. The fact that there is a pulse of fish right after the rain could indicate that at least some of the Chinook wait for higher flows before starting or continuing their downstream migration.

POSSIBLE OVERALL FLOW EFFECTS

It could be possible that during low flow years, juvenile Chinook salmon tend to have a slower downstream migration than in normal years. This could be because they are waiting for big flows to travel with. It could also be possible that low flow could explain the high degree of Chinook disappearance in the upper river. Over the course of the next 2 years, we hope to have medium and high flow years to verify these hypotheses.

FUTURE OBJECTIVES

Over the next 2 years, we will be trying to improve our error bars in the lower system by hopefully allowing more detections in the delta and bay. This will be done by increasing the number of monitors, increasing the number of tagged Chinook, and releasing in several locations along the river to allow for a more evenly distributed flow of fish.